ProOrg Work package 3 (WP3) | Deliverable 3.2

Case Study

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1. Assessment framework

1.1 Introduction

The Assessment framework represents a generic guideline and sets the minimal requirements for the assessment of processing technologies in the context of organic food processing.
The main objective of the Assessment Framework is to provide guidance on how to assess quality of organic food as affected by processing technology. It further provides guidance on how to compare different processing technologies and raw materials.
In the Assessment framework, organic food quality is defined through specific aspects. For the assessment of organic food processing, three aspects are considered: environmental sustainability, nutritional quality and sensory quality.
The assessment process consists of three main steps: 1) establishing the context, 2) assessment, and 3) overall evaluation. Establishing the context assures profound system understanding of the case for which organic food processing needs to be assessed and it involves identifying the importance of the different aspects and defining the system boundaries. Assessment involves characterization of criteria, indicators and parameters necessary to perform the assessment and collection of data. Overall evaluation is the final step, where individual criteria must be weighted for a specific organic product under study, followed by calculating the overall score. Based on this overall evaluation, a decision can be made.

1.2 Assessment protocol

The Assessment framework gives an extensive overview of the theoretical and practical underpinnings of the assessment process. To attract companies to use and test the framework, and to allow for a faster and more straightforward assessment process, the need to develop a simplified assessment protocol was identified. The structure of this assessment protocol follows the three main assessment steps: 1) establishing the context, 2) assessment, and 3) overall evaluation. Each step consists of multiple substeps with shortly described tasks that need to be performed and written down into a belonging Excel file.
The assessment protocol was designed for use in workshops with companies. The first two steps are performed in the first workshop, after which the company needs to collect data necessary to perform the overall evaluation. The last step is performed in a second workshop.

1.2.1 STEP 1: Establishing the context

The aim of this step is to characterize different aspects of organic food quality (i.e., sustainability, nutritional quality, and sensory quality) that can be affected by product processing and to identify reference raw materials for the naturalness check. Moreover, the aim is to define a system boundary.
This assessment step includes the following substeps:
Substep 1.1.

a) Choose a processed organic product for which you will perform an assessment and choose your main objective of the assessment
b) List processing steps of an existing processing method for this product
c) List inputs and outputs for each processing step
d) Choose an alternative processing method for the product you selected. List processing steps for production of this product.

e) List inputs and outputs for each processing step.

f) Identify reference raw materials for the chosen processed product.

Substep 1.2.

a) For each of the three aspects (nutritional quality, sensory quality, sustainability) determine what criteria are affected/are changing during processing of the product

b) Explain shortly how and how much are selected criteria affected during processing (for both existing and alternative processing method)

c) Select which nutritional and sensory criteria and why are suitable to compare quality of raw materials and processed products.

Substep 1.3.

a) Draw a system boundary around those processing steps and criteria that you will consider in your assessment.

b) For any processing steps and criteria that are outside of the boundary, explain in written form why they are not being included in the assessment.

1.2.2. STEP 2: Assessment

The aim of this step is to characterize the relevant criteria identified in step 1 by identifying suitable indicators and parameters for each criterion.

This assessment step includes the following substeps:

Substep 2.1.

a) For all criteria that are important for the assessment, choose indicators that sufficiently describe those criteria for both the existing and alternative production methods.

b) Choose parameters that can be used to quantify indicators identified in substep 2.1.

Substep 2.2.

a) To compare raw materials with a processed product, you will use criteria and indicators that you listed for nutritional and sensory aspects. List those indicators in a separate sheet.

Substep 2.3.

a) Determine numeric values of parameters for all identified indicators separately for an existing and an alternative processing method. These are the absolute indicator scores needed to perform step 3 of the assessment

b) Additionally, determine numeric values of parameters for all identified indicators for raw material(s).

1.2.3. STEP 3: Overall evaluation

The aim of this phase is to evaluate the criteria selected in step 1 and to decide which processing method for the chosen organic product is more in line with organic food quality

Substep 3.1. instructs how to transform numeric values of indicators that were determined in substep 2.3 (absolute indicator score) to criterion scores (see figure 1).

Figure 1. Path from absolute values of indicators to the criteria score need to perform the overall evaluation

Substep 3.2 instructs how to transform criterion scores into aspect scores
Substep 3.3. instructs how to transform aspect scores into an overall score.

Full text of the Assessment protocol can be found in supplementary material, together with the belonging Excel file (Assessment Table) to insert results of the assessment.

1.3 Towards online workshops

Due to the ongoing COVID-19 situation, it is no longer possible to perform on-site workshops with companies. Therefore, the Assessment protocol was adapted to allow for online workshops by using Microsoft Teams software. The Assessment protocol and the belonging Excel file were revised to determine their suitability for their use in an online environment. Only minor changes were made, i.e. indicating more explicitly in the Assessment protocol where the results of each task need to be inserted in the Excel file. This was done since it is not possible for a workshop leader to physically indicate such things in an online workshop. Furthermore, a questionnaire for group discussion in the end of workshop 1 was developed. This is a group discussion where workshop participants get a chance to state their opinion about the Assessment protocol and the assessment process.
Lastly, since it is difficult to have a good understanding of the extent to which each workshop participant shared their opinion in the group discussion, an online survey was also developed. This survey follows the format of the questionnaire for group discussion and it is sent to all participants after the first workshop.
Since the workshops are to be performed in Denmark, France and the Netherlands, a document with instructions for leaders of workshop 1 was also developed, to assure that all workshop leaders perform their workshops in as uniform way as possible.

Supplementary material contains the following files: Instructions for online workshop 1, Group discussion questionnaire and Online workshop 1 evaluation survey.

2. Cases

2.1 Team Denmark

2.1.1 Introduction

Activities to recruit companies to the case studies included a visit at BIOFACH food fair in Nürnberg, February 2020 were the project was presented to Danish food processing companies and a project leaflet with information about the project was handed out to those interested in the project. In addition, a newsletter about the project addressed to companies was published at the website of CORE Organic Cofund. A list of relevant Danish food processing companies was made, and companies have been contacted via e-mail/phone. Initially a number of companies has showed interest in the project, but when explaining the purpose of the case studies and the part where companies have to collect data themselves, some lose interest in participating. Some of the major reasons for companies not to want to participate is due to lack of time and resources or that they do not have a wish to change any step in their production. In general, a large interest in the project was seen from start-up companies. Some companies have stated that they do not have time for the project at the moment or some wishes to look further into the possibility for them to do some practical testing of the technologies that they wish to evaluate before signing up for the project.

2.1.2 Dairy case (study)

Company recruitment, company characteristics, description participants (functions)

An online workshop with a large Danish dairy company was conducted in May 2020. Prior to the workshop online meetings were held with two representatives from the company and details about the workshop were discussed. The representatives suggested that a number of other employees from the companies participated to include participants with different backgrounds in the workshop. A total of eight people working with different areas of the company participated in the workshop. Their functions in the company were within sensory and consumer science, product and process design (two participants), food ingredients R&D (two participants), nutrition specialist, food chemistry and organic certification.

Technical meeting aspects; execution online due to Covid-19, tools

Due to the Cov-19 outbreak the case study was conducted as an online case study. The workshop was conducted using Microsoft Teams software as well as Google Documents and an Excel file, which were shared in Microsoft Teams so that the participants could assess it from their own computer.

Setup workshop

include:

- ProOrg team and roles
- Program
- Way of working (warm-up activity, workshop was recorded, transcribed and analysed etc)
- Start (instructions)
- Execution
- End workshop (group discussion, survey outline (survey can be in appendix))

The ProOrg team consisted of Andrijana Horvat (WUR), who was the facilitator of the workshop and Lilia Ahrné and Caroline Christensen (KU), who's roles were to clarify for the company if they had questions about the background and purpose of the project as well as to assist in case of technical issues.
The workshop was scheduled to three hours and screen and audio was recorded, so that the workshop could be transcribed and analysed afterwards. The program of the workshop was presented and was as follows: Introduction of the project (around 15 mins), followed by an warm-up activity where the participants were able to share their hopes and fear about the workshop in a Google Document, which they could access from Microsoft Teams (around 15 mins), afterwards the participants were asked to list processing steps of the processes they had to choose to evaluate, which were done in an Excel document (around 45 mins). Then a break of 15 mins were scheduled, following this the participants were asked to list criteria, indicators and parameters using the Excel document around (45 mins), then another break was scheduled (15 mins). To round up, there was a focus group discussion where the participants were asked to share their experience about the workshop (around 20 mins) and in the end the facilitator explained about how the participants can access the documents that were used in the workshop and how to collect data for the next steps of the case study (around 10 mins).
During the workshop one of the participants was assigned as the leader and were responsible for typing in the Excel file while sharing the screen with the other participants. The participants were presented to each task and were asked to go through the steps and fill out the corresponding fields in the Excel file. The workshop facilitator only intervened if the participants needed help or made a mistake.

The day after the workshop the participants received an online survey with questions similar to the ones asked in the group discussion. E-mails were sent out three times in total reminding the participants to answer the survey. The recording of the workshop was transcripted and analysed using an analysis form. In this document it was noted how long it took for the participants to go through each step of the protocol, whether the facilitator had to intervene the participants and clarify a task, correct any mistakes and so on.

Findings

- Positive and negative technical aspects

The use of Microsoft Teams as well as the other software tools were overall successful. A few participants experienced problems accessing the Google documents that were shared in Microsoft Teams. To our knowledge all the participants had previous experience with working in Microsoft Teams, but some of them were more experienced than other. A negative side to this type of online workshop is that it is difficult to engage everyone to the same extent because it was not possible to see what people were actually doing while the workshop took place.

- Comments to the framework (theory, tasks performed, general)

The participants had some comments to the framework. On theory level some participants questioned how and why the three aspects of organic food quality had been chosen. One participant found that the consumer part was missing. Another participant mentioned that Life Cycle Analysis seems comparable with the framework. Other comments were that it will be difficult for a company to collect data especially on the sustainability part since it is very broad.
Some of the comments to the tasks performed were that the participants had difficulties understanding some of the wordings like "input" and "output" as well as "parameter" and indicator". On the last two wordings a participant suggests renaming these to make them easier to understand. In addition, some participants found that the Excel document were

difficult to navigate in, and that it could be made easier to use by renaming some of the fields.
Some of the general comments to the framework were that the work that needs to be done is too complex. It was suggested to make the evaluation of technologies more superficial and to ease up on the degree of detail needed and instead work with rough estimations.

- Brief survey overview

The participants received a link to an online survey where they were asked questions about their experience of the workshop. A total of three people answered the survey. In the survey the participants were asked about the difficulty of the tasks they went through in the workshop and in substep 1.1 "Listing of inputs and outputs of the existing processing method" and "Listing of inputs and outputs of the existing processing method" were each scored "very challenging" (score 4/5) by two participants and "moderately challenging" (score 3/5) by one participant. Some of the other tasks e.g. "Selecting indicators for environmental sustainability criteria" were scored to be "extremely challenging" (score 5/5) by three participants (See survey answers in Appendix).
After the first workshop the company stated that they will not participate in the following workshop since they do not see the relevance of this for their needs.

2.1.3 Plant-based drink (pilot)

In March 2020 a pilot study was held with a Danish start-up company producing plant-based drinks. One person from the company participated in the workshop and two and a half hours were scheduled for the workshop. The facilitator was Caroline Christensen (KU). The participant from the company were the founder and worked with product development. The participant did not have a scientific background, which gave some challenges in selecting the appropriate criteria for the technologies and also the participants did not have any employees who could support this. Six weeks after the workshop the company was not able to collect any data to be used for the second workshop. The participant did not know how to collect data and did not have resources for having their product analyzed anywhere outside of the company. Assistance was provided with looking into scientific literature, but no useful data relating to the chosen product could be found. The participant stated that the person did not see the immediate value to spend time on the project and did not wish to continue in the project.

2.2 Team France

ITAB French team associated with this task is composed by one engineer in charge of organic quality and processing method assessment and one PhD on sensory evaluation.

2.3.1 Introduction

The French partner ITAB had to recruit companies in order to test the AF on practical case studies. At national level, ITAB is co-animator of a national network dedicated to organic processing. This network is very active and each members have their own companies contacts. So we use this network to communicate about the project and to identify companies eager to test the AF on their own food product.

From October 2019, ITAB participate in 15 events including (4 conferences or webinar ; 6 mailing campaigns to food and/or organic networks; 1 press articles and 2 news for professionals). During this events, we introduce ProOrg project and ask whether companies would like to apply the assessment methodology. At a first glance, companies where really interested in the project but most of them did not plan to develop new products or test alternative process so where not able to participate in the AF test.

Recruitment activities

Date	Support
21/10/2019	Présentation Natexpo, Paris
29/11/2019	L'Agro's Groupe (Facebook Alumni Agro)
04/12/2019	Mailing partenaires RMT
04/12/2019	Actualités sur site RMT TransfoBio
09/12/2019	Post LinkedIN
12/12/2019	Distribution Flyer – Blédina, Brive la Gaillarde
08/01/2020	Mailing liste formation du valentin
08/01/2020	Mail à Jean Verdier ex-pres du synabio
09/01/2020	Mailing Synabio - Bernard Lignon
09/01/2020	Mail incubateur APT
09/01/2020	Mail incubateur ISARA
15/01/2020	Article Presse "Les Marchés"
11/02/2020	Présentation Colloque RMT TransfoBIO, Arras
21/02/2020	Webinar ClusterBio
16/06/2020	GT Qualité Synabio

17 companies have been individually contacted to participate after their own feedback interest. For each, we dedicated a least a call meeting to begin to fulfil the AF. Only 6 companies get further, with below are the most advanced cases.

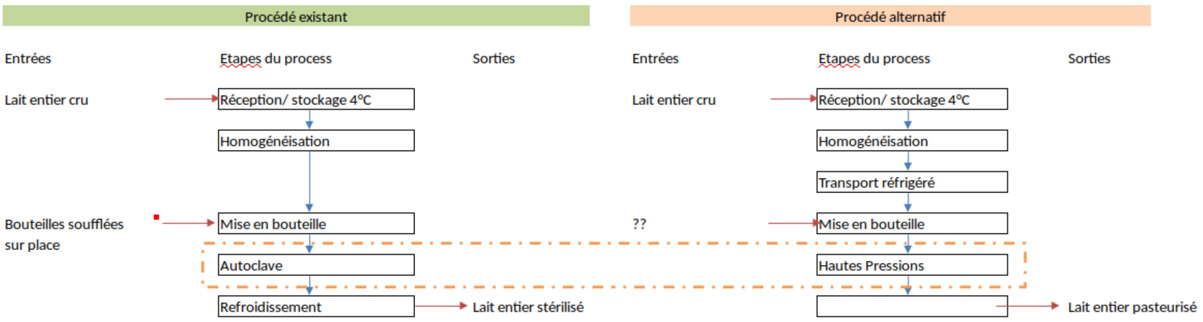
2.3.2 Cookie case (pilot)

A first company (cookie dough processor) contact us to follow the plan. After a first physical meeting with the team, it was clear that the food process assessment was not design for them as their main activity was a formulation one i.e. they sell uncooked cookie dough for homemade cooking. Unless the difficulty to use the AF, we tried to test only naturalness of their product. Processing diagram have been elaborated without any alternative process but with different ingredients (raw or refined almond powder for example).

The test has not reached further steps due to a lack of time of company team, a difficulty to use the results as a marketing argument.

2.3.3 Milk case (pilot)

A milk collector who sell dairy product was interested in developing a new process for their milk stabilization. They would like to test HPP instead of HTST for the microbiological treatment of the milk. This case was exactly in line with the AF : diagram of ongoing process and expected alternative were built and indicators were set up and validated.



However, milk collector have been widely impact by COVID-19 crisis and the company gave up the new product development. We do not have any news from them so far.

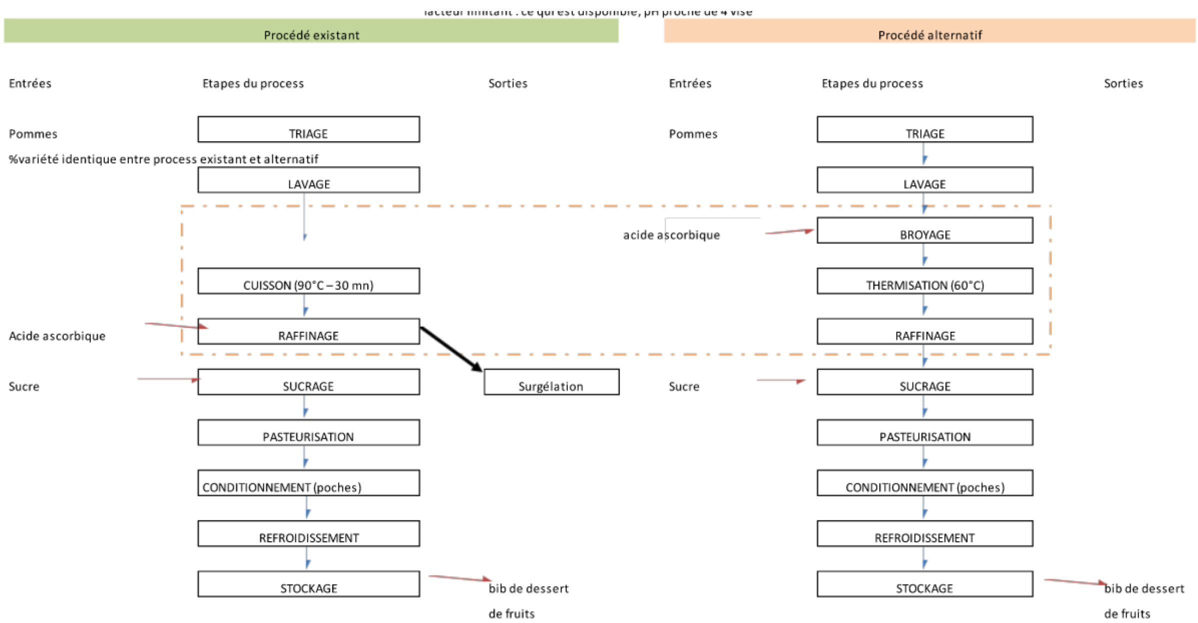
2.3.4 Apple puree case (pilot)

A technical high school was also interested in testing the AF as they would like to enhance their apple puree processing. They produce organic apple on site and they use sorting deviation apple to process them into puree to sell in their own school shop.

Their process so far is not well optimised on nutritional quality and they would like to avoid additives so they want to test an alternative process as a proof of concept and as a final guidance for their direction.

High school test is a good manner to test the AF because students can do most of the analysis.

Diagrams are done, indicators are validated but the exact equipment to test is not yet fully described. The analysis are planned in winter 2020.



2.4 Team Germany (pilot study grain milling)

The head of the German team is Dr. Alexander Beck from the AöL and is conducting a case study in the context of a master thesis with the FH Münster (MSc student Pia Uthe). The AF is carried out on two alternative processing methods of a German organic bakery.

2.4.1 Introduction

In this pilot study the AF was applied and evaluated in a company. Practice partner: Märkisches Landbrot (organic Demeter bakery). Here two alternative grinding methods were compared and analysed using the AF. Afterwards an evaluation of the application was carried out.

2.4.2 ProOrg team and roles

The bakery build an expert team (exist of the Operations Manager, Production Manager and the internal miller). The master student took the position of the project manager. She planned the procedure, prepared the meetings and made first drafts for the individual phases, which were then discussed and developed further with the team of experts in the meetings. Dr. Alexander Beck made the cooperation with the bakery possible because Märkisches Landbrot has long been a member of AöL.

2.4.3 Program and workshops

The three phases were carried out between October 2019 and April 2020, before the COVID-19 pandemic began. The time schedule is shown in figure 1. A total of six workshops took place on site in the bakery with the expert team of the bakery and the master student.

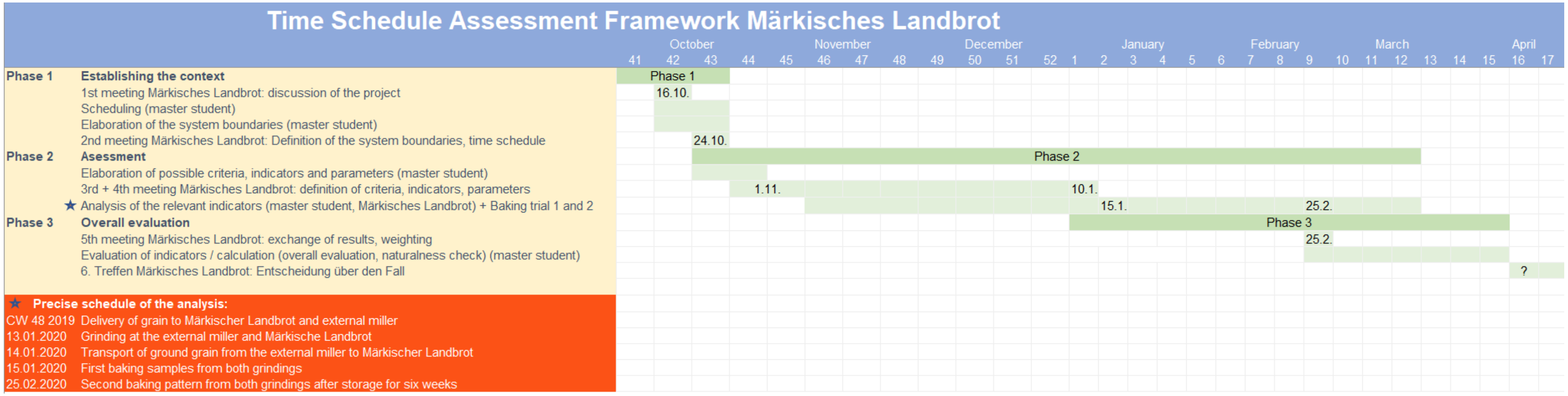


figure 1:Time schedule of the application of the AF in the bakery (October 2019 - April 2020)

The workshops were not recorded and transcribed. But there are protocols for the documentation.

2.4.4 Start Instructions

In the first meeting in October 2019 the project and the planned application of the AF were presented and explained to the expert team.

2.4.5 Execution

Phase 1:

For the application of the AF were chosen the following two alternative processing methods of grain milling (see figure 2). The *procedure 1* is the traditional processing method; this is milling the grain in the internal stone mill of the bakery. For this procedure, grain is delivered every week from the farmer to the bakery. The *procedure 2* is the new processing method. There, a larger amount of grain is transported from the farmer to an external miller every five weeks, where the flour is milled using a modern roller mill. The flour is then transported to the bakery.

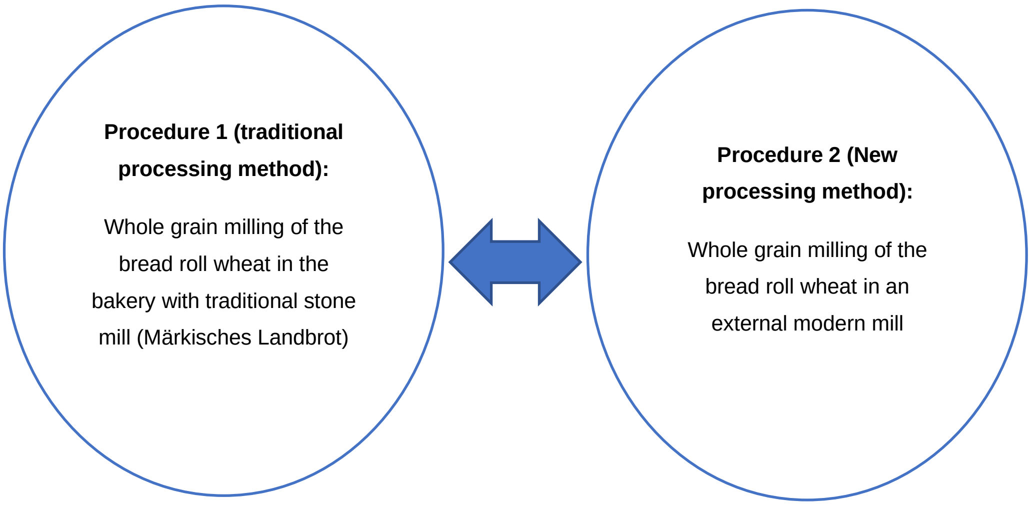


Figure 2: The two procedures for the application of the AF in cooperation with the AF. Traditional processing method and new processing method)

The system boundaries were determined. The project manager made a draft, which was then discussed in a meeting between her and the bakery's team of experts. The final documentation of the system boundaries is showed in figure 3.

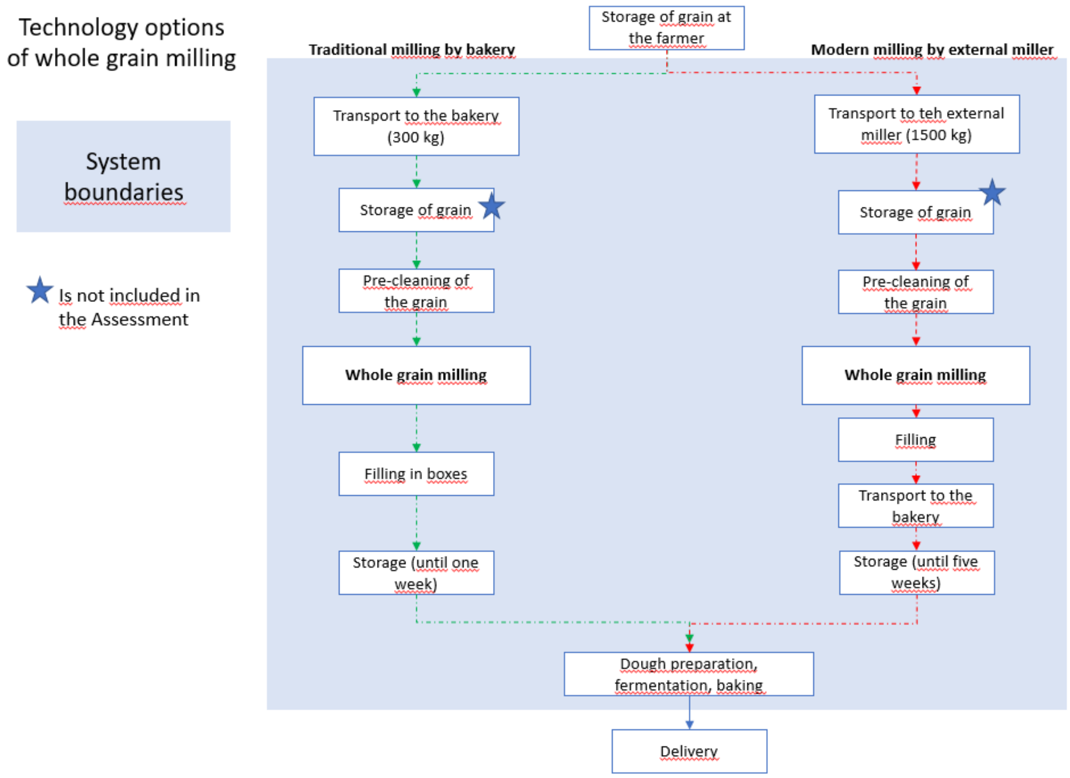


Figure 3: Phase 1: System boundaries of the two processing methods

<u>Phase 2:</u>
To carry out the second phase a draft of criteria, indicators, parameters and methods of analysing has been worked out by the project manager and was discussed in a meeting between her and the expert team of the bakery.

The analysis of the indicators was then carried out. The ecological indicators were measured in the form of a questionnaire for the bakery and the external miller. The nutrient quality was measured by applying the two milling methods and thus milling the grain. The flour samples were then sent to a laboratory and analysed for selected micro- and macronutrients. The sensory quality was investigated by carrying out two baking trials at an interval of six weeks. Wholemeal rolls were baked and then tested in the laboratory for sensory quality.

<u>Phase 3:</u>
For the third phase the values of the analysis were entered in an excel table which was created by the project manager. The values were normalised, assigned by rating and an overall value was calculated.

2.4.6 End workshop

In the end of the workshop an evaluation of the application was carried out in cooperation with the expert team of the bakery and some ProOrg members. For the evaluation in cooperation with the bakery a questionnaire was created, which was filled in by the bakery. Also additional correspondence was required in order to describe some points more in detail. For the evaluation in cooperation with ProOrg members was created a second questionnaire. Also a description of the application of the AF was created. The aim of this questionnaire with ProOrg members was to include them in the application and to give them a better overview about the application. Also they should evaluate if the application is carried out according to the AF and use the knowhow to get a feedback. The points were identified from the evaluation are described in chapter 3.4.7.

2.4.7 Positive and negative technical aspects, Comments to the framework

<u>What works in which context:</u>

- The structure of the individual phases of the AF provided a good basic framework for the application of the evaluation system.

- The elaboration of these phases on the basis of literature is not possible due to the specific and complex processing procedures. For the individual phases, that is:
    1. Definition of the system boundaries
    2. Definition of criteria, indicators and parameters
    3. Weighting of indicators, criteria and aspects

    were prepared drafts by the Master student. These were constructively discussed and finalized in cooperation with the expert team of the Märkische Landbrot. This led to the successful development of the individual phases.
    →Without these drafts and the support of the master student, it would have been much more complicated for the practice partner
    →Expert monitoring would be a major asset for the application of the AF
    →Of course there is a lack of both scientific traceability and objectivity, but this is sufficient for internal company needs.

- Some indicators were not measurable, which would actually be very important for the evaluation (e.g. electricity consumption)
    → In order to avoid that important indicators are not included in the evaluation due to missing measurements and that the meaningfulness of the AF is thereby reduced, alternatives can be implemented.
    <u>The following alternatives could enable measurability</u>
    - E.g. the specific power consumption could be made comparable based on device data
    - It could be notionally assumed that the overall electricity consumption of large machines is lower in relation to small machines. Based on a critical explanation, a rating value could then be "assumed

    → However, the AF must officially provide flexibility, freedom, case studies and guidance.

What works but needs improvement:

- Weighting can be set successfully in a company by a competent team based on the quality policy set up. The interaction with organic principles stays a critical point. It is not clear how to take care for the principles by setting criteria and weighting.

  → Improvement: Availability of a checklist/guidance for weighting the indicators, criteria and aspects according to the principles of EU organic legislation

  Example of such a checklist:

  1. Which ecological indicators / criteria have the highest impact on the environment?
  2. Which nutrient qualities have the highest health impact on the consumer?
  3. Etc...

- The weighting is difficult to make with the help of literature. In cooperation with experts (external and from company), each weighting would probably look different and thus reduces the objectivity of the result. Of course, this lacks both scientific traceability and objectivity.

- In the case of the Märkisches Landbrot, the technological flour quality (for example Particle size distribution, dough stability, water absorption...) plays a primary role for the bakery, but it is not part of the evaluation system. For such cases there should be a general instruction in the AF how to deal with.

  Improvement: It could be considered whether, in addition to the three aspects (environmental sustainability, nutrient quality and sensory quality), defined in the AF, could be added further aspects (perhaps one or two) depending on the processes.

  → The Weighting of these special aspects could be restricted (for example not more than 15 %)

- At the beginning of the application of the AF it was difficult to communicate the approach, goals and tasks of the AF clearly to the expert team. The understanding increased as the application progressed.

  Improvement: Perhaps an explanation could be created here, which would give the company a good insight into the goals, procedures and possible outcomes at the beginning. A great idea is an explanation video with examples, as suggested in the meeting on Thursday

- The inclusion of "naturalness" is not always necessary or feasible In the case of flour milling, for example, it does not always make sense to taste the milled grain, but rather the sample rolls from the baking test

  Improvement: The AF must officially provide flexibility, freedom, case studies and guidance

- The calculation is of the evaluation of phase 2 and the overall evaluation of phase 3 is very complex
  Improvement: For the calculations there should already be a pre-structured system in which the values only have to be entered and which then calculates everything (for example an excel table).
  →However, there would also has to be room for flexibility, because in processing procedures, there is always something that requires a different calculation method. For example, in the case of milling processes, the inclusion of the technological flour quality, i.e. the aspects might even have to be extendable

- The rating is not generally applicable in this form and needs improvement:
  1. Division into environmental sustainability on the one hand and nutrient quality and sensory quality with reversed signs on the other. There are exceptions where this does not work: For example: A lower share of renewable energies is also negative

	Environmental sustainability	*Nutritional / sensory quality*
Rating scale	*Condition for HPP - normalized value*	*Condition for HPP - normalized value*
2= far better	<50	>150
1= better	≥50; <100	>100; ≤150
0= same	100	100
-1= worse	>100; ≤150	<100; ≥50
-2= far worse	>150	<50

Aspekt	Criteria	Indicator	Parameter	VTW Absolute Value	VML Absolute Value	VTW Normalised Value	VML Normalised Value	Rating
Ecological Quality	Energy	Electricity consumption	kWh	60	40	150,00%	100%	-2
		Parts of electricity from renewable energies	%	80%	100%	80,00%	100%	?

  2. The rating is not fine enough not sufficient explained. Values are very close together (see VTW normalised Value) but very far apart in the rating. This means the rating system needs to be further developed and explained.

Indicator	Parameter	VTW Absolute Value	VML Absolute Value	VTW Normalised Value	VML Normalised Value	Rating
Vitamin B3 (Niacin)	µg / 100 g Mehl	105,0	104,5	100,48%	100%	1
Raw protein	% i.T.	12,00	12,5	96,00%	100%	-1

3. The rating does not increase proportionally: 2 and -2 do not show the true distances: Example 1075.00 % and 27.78 % is 2 and -2

Indicator	Parameter	VTW Absolute Value	VML Absolute Value	VTW Normalised Value	VML Normalised Value	Rating
Mineral nutrients	% i.T.	-0,05	-0,18	27,78%	100%	**-2**
Vitamin B2 (Riboflavin)	µg / 100 g flour	4,10	0,40	1025,00%	100%	**2**

→ All in all the rating has to improved! It needs examples / case studies and guidance for a successful application

2.4.8 Conclusion

Overall, the application of the AF has worked well. Due to lack of experience in the application of the AF, its implementation required a lot of time and structural considerations. Especially in the documentation of the results.

2.5. Team Italy (Case fresh-cut industry)

2.5.1 Introduction

In the processing of fresh-cut products, the washing step is carried out to precool the product, remove dirt, pesticide residue and cell exudates that may promote microbial growth, and to reduce the bacterial load, formed by pathogenic and spoilage microrganisms (Holvoet et al., 2012). It is an unavoidable intervention step when Ready-To-Eat (RTE) vegetables to be consumed raw, are to be produced. In some cases, leafy vegetables, e.g. baby leaves, are marketed unwashed, packaged in trays wrapped in film to keep physical damage of leaves to a minimum and to prevent wilting of leaves from loss of water (Løkke et al., 2012). However, these products certainly cannot be considered as Ready-To-Eat products and do not match a general definition given by the International Fresh-Cut Produce Association, according to which fresh-cut or minimally processed vegetables are “any fresh fruit or vegetable that has been physically modified from its original form (by peeling, trimming, washing, and cutting) to obtain 100% edible product that is subsequently bagged or prepackaged and kept in refrigerated storage” (Rojas-Graü et al., 2011).
In the processing of fresh-cut products, the washing step has a crucial importance for its key role in determining the safety and quality of the end product, and has the largest implications on the environmental sustainability of the whole process (Fusi et al., 2016). The microbial quality of washing water is of utmost importance, because when the water in the washing baths is not changed often enough, microrganisms accumulate giving rise to an increasing total microbial load in the washing water during production. This may cause cross-contamination of the fresh-cut produce at the washing step, affecting the microbial quality of the end product. Thus, according to some Authors wash water disinfection is needed to avoid cross-contamination between

contaminated and uncontaminated plant material and is an unavoidable intervention (López-Galvez et al., 2019). The overall water consumption depends on the rate of water turnover in the washing tanks and, in turn, this rate depends on the efficacy of the disinfection treatment applied. The more efficient disinfection, the lower risk of contamination and the lower rate of water turnover may be applied, thus reducing water consumption. As remarked by other Authors the disinfection treatment of washing water has the sole objective of reducing the overall amounts of potable water required for the washing operation (Manzocco et al., 2015). However, it is not clear from the literature, first, the amount of potable water needed to be used in washing without disinfecting agents to guarantee an appropriate level of product microbial quality, and thus safety, second, if washing with potable water, without any disinfection treatment, is able to assure the required level of food safety at all (Holvoet et al., 2012).

Chlorine is the most widely used disinfectant in the fresh-cut industry, but its use is forbidden in organic production in Europe, and also for conventional products in some European countries (Germany, Switzerland, Netherlands, Denmark and Belgium), due to environmental and health risks related to its use. Environmental and health risks are associated to the formation of halogenated disinfection by-products, which are formed by the interaction of chlorine with plant organic matter and may residue on end products and waste water (Coroneo et al., 2017; EFSA, 2015; Garrido et al., 2019; Gil et al 2016). According to the IFOAM norms for organic processing "techniques used to process organic products shall be biological, physical, and mechanical in nature. Any additives, processing aids, or other material that reacts chemically with organic products or modifies it must be organically produced or appear in Appendix 4 Table 1 and shall be used in accordance with noted restrictions" (IFOAM, 2014). At present the only disinfectant suitable to fresh-cut processing and allowed to be used in direct contact with food by the IFOAM norms are the organic acids (e.g. citric, lactic) which are also in the GRAS (Generally Recognised As Safe) status. However, the limited antimicrobial activity of these substances, makes the exposure times needed for a significant reduction of the microbial load too long to be relevant for a processing line in the food industry (Ölmez et al., 2009a). Washing with potable water without addition of disinfectant chemicals has been reported as a process used by processors of organic fresh-cut products. For this reason, washing with tap water has been selected as a benchmark in this assessment (WW: Water Washing – Benchmark 1), as a washing treatment allowed for the organic sector. However, a study carried out on the processing lines of two processing companies in Belgium, where chlorine use is not allowed, has highlighted that the washing operation without the use of any disinfectant may result in increased, rather than a decreased, contamination of the end product, when the water in the washing tanks was not changed often enough (Holvoet et al., 2012). As a consequence, according to these Authors, the wash process with potable water cannot be considered as an intervention step in the fresh-cut industry. In addition, as mentioned above, the use of water without disinfectants implies the consumption of high volume of potable water and the production of large amounts of waste water, while according to IFOAM principles "Organic farming methods conserve and improve the soil, maintain water quality and use water efficiently and responsibly" (IFOAM, 2014). In the literature search performed for this assessment, no data have been found regarding the amount of potable water used in processing of fresh-cut products when no disinfectant chemical is used in the washing step. Thus, based on this lack of information, it is not clear whether this approach is the best one for the organic processing of fresh-cut products.

At present, none of the disinfection treatments allowed for organic products show enough microbial action at the permitted usage level. Nevertheless, the washing treatment with ozonated water has attracted attention for efficacy in reducing pathogenic microorganisms, formation of disinfection by-products and cost factors, and it has been proposed as a “best available technique” for the disinfection of vegetables (Ölmez & Kretzschmar, 2009a). Washing with ozonated water is a chemical disinfection method, whereas according to the Specific principles applicable to processing of organic food (EC, Regulation No 834/2007) “the processing of food with care, preferably with the use of biological, mechanical and physical methods”. However, ozone has been classified as GRAS (Generally Recognised As Safe) as a sanitizer or disinfectant for foods when used at levels and by methods of application consistent with Good Manufacturing Practices. Following the GRAS declaration of ozone, the US Food and Drug Administration (FDA) has approved the use of ozone in the treatment, storage, and processing of foods, including meat and poultry, as well as raw agricultural commodities (CFR, 2009). Thus, this technology has been selected as the new technology for the present assessment (OWW: Ozonated Water Washing).

In addition, due to the present lack of an efficient disinfection treatments allowed for organic products, the chlorine based washing treatment has been considered as a second benchmark (CW: Chlorine Washing - Benchmark 2), since it is the mainstream option followed in the conventional fresh-cut industry for the efficacy in reducing pathogenic microorganism and cost effectiveness and because a lot of information is available in the literature on the effects of this process.

In summary, the washing step in the processing of fresh-cut products through the use of ozonated water (OWW, Ozonated Water Washing) is used as case study to illustrate the application of the Assessment Framework (AF) for the Evaluation of Organic Food Processing by following the step-by-step procedure described therein. In the AF this process has been compared with washing by potable water (WW, Water Washing - Benchmark 1), and washing by chlorine (CW, Chlorine Washing - Benchmark 2), considered as benchmarks within Step 2 of the assessment process, to establish if it is more in line than the benchmarks with the concept of organic food quality.

To specifically evaluate the naturalness of the fresh-cut products washed by OWW, a comparison with the raw unprocessed material is needed. These comparisons allow to evaluate whether OWW washing is superior than washing by WW or CW in terms of naturalness, for the considered indicators, and to what extent if fulfils the requirements for naturalness.

The purpose of this example is to illustrate the assessment process from Steps 1 to 3, up to Substep 3.4 as described in the Assessment Framework for the Evaluation of Organic Food Processing. Substeps 3.5 to 3.6 are important for the overall decision but are not part of the assessment process. Therefore, they were excluded in this example. Furthermore, as for this case example many assumptions were taken arbitrarily (e.g., regarding the different weighting factors), the result cannot be taken for a real evaluation of OWW treated fresh-cut products.

2.5.2 Execution

Step 1. Establishing the context

Substep 1.1 System understanding

The production process of fresh-cut vegetable generally involves the following steps:

1. Receipt and inspection of the raw vegetable

2. Cold storage of the raw vegetable

3. Product preparation, through the operations of cutting, coring, grading, etc.

4. Size reduction by hand-removal of wrapper leaves, or chopping, dicing, slicing.

5. Washing/disinfection

6. Dewatering

7. Packaging

8. Cold storage of the packaged product

9- Distribution.

In the present case study, the production process will be analysed in relation to the processing of lettuce (*Lactuca sativa* L.), as one of the most common fresh-cut leafy vegetable available on the market. In particular, the object of this assessment will be focused on the step of washing/disinfection and three washing/disinfection treatments in processing of fresh-cut leafy vegetables will be compared:

- Washing with ozonated water, as the new washing treatment to be evaluated in the context of organic food quality;
- Washing with potable water, as the benchmark representing the existing washing treatment used in the organic processing sector;
- Washing with chlorine, by addition of sodium hypochlorite, as the benchmark representing the most common washing treatment used in the fresh-cut industry for conventional products.

Apart from the washing treatment, there were no differences between the three considered processes.

As a reference raw material to evaluate naturalness, raw, unprocessed lettuce leaves could be used. As literature values for the relevant indicators were found for untreated lettuce leaves, this was taken as a reference to check for naturalness.

Substep 1.2 Preliminary criteria relevance check

As mentioned in the Introduction the washing step is known to have a crucial impact on food safety and quality, and on the environmental sustainability of the whole process. As regards environmental sustainability, Life Cycle Assessment investigations have highlighted that the environmental impact associated to the fresh-cut industry is heavily influenced by the processing phase, mainly the washing and packaging operations, due to electricity and water consumption (Fusi et al., 2016). The water consumption and waste water volumes are in the range of 2.4-11 m^3 and 11-23 m^3 per tons of product for the fruit and vegetable processing industry. Thus, there is a need to develop alternative technologies with the aim to reduce water consumption and waste water generation rates, and to improve the quality of waste water. Washing and sanitization operations account for almost 70% of the total water used during processing. In particular, in the case of processing of fresh-cut leafy vegetables, almost 90% of water is used for washing and rinsing, and more than the 90% of the organic load of the waste water is produced during the processing stage (Ölmez, 2017). It has been also reported that for a sustainable management of water use the waste water quality is the most important factor, because the main industrial impact on water resources is due to the highly polluted waste water discharges rather than the amount of water used. Key pollutants present in waste water are the organo-halogens, which are mainly associated with the use of chemical sanitisers, mostly with the chlorine based sanitisers in the case of fruit and vegetable processing (Ölmez, 2017). In addition, it has to be considered the global organic load of the waste water due to the organic matter released during the washing process. Another aspect of the impact of water resource consumption and waste water discharge is related to the fact that in most cases the fresh-cut industry has developed in the form of quite specialised and localised industrial districts, which implies that environmental impacts tend to concentrate on relatively small geographical areas (Caponetti, 2013).

As regards intrinsic quality attributes of food product it has to be noted the relevance of the microbiological quality in the case of fresh-cut products. Even though the item "microbial characteristics" is included in the list of suggested criteria related to the aspect of nutritional quality in the Annex I of the AF document, in the specific case of fresh-cut produce it seems that microbial quality should be considered as a sort prerequisite for the evaluation of any technological approach, rather than one of the criteria among the others included in the list to evaluate the aspect of "nutritional quality". Fresh-cut products are highly perishable products that are generally sold as ready-to-eat food products and in many cases are consumed in the raw state. As a consequence, their microbiological quality is a crucial mandatory prerequisite for their food safety and marketability. Thus, when comparing different technologies for this assessment, it should be possible to established for them, as a starting point, conditions assuring the same level of microbial quality, and thus safety, of the end products. However, this is not feasible based on data available in the literature which, on the contrary, highlight that the different considered washing treatments have a substantially different impact on product microbial quality, in particular, when comparing OWW, or CW with WW (Holvoet et al., 2012; Lopez-Galvez et al., 2019). This seems to represent a specific challenge to be faced in the application of the AF to the sector of fresh-cut processing.

In addition, both nutritional (vitamin content, level of phytochemicals and contaminants) and sensory (appearance, texture, aroma and off-flavour formation) quality are significantly affected by the washing step, as demonstrated by many experimental studies carried out in laboratory pilot scale conditions Beltrán et al., 2005; Ölmez et al., 2009b).

Regarding the check for naturalness, when data were available in the literature, all indicators considered within the nutritional and sensory quality aspects are suited to compare the processed fresh-cut product with the raw untreated leafy vegetables.

Substep 1.3 System boundary setting

The system boundaries are set around the washing/disinfection step, which involves the three technology options compared (Figure 1), because all the other steps of the process are the same for the three approaches. Thus, all the other steps lie outside the system boundaries.

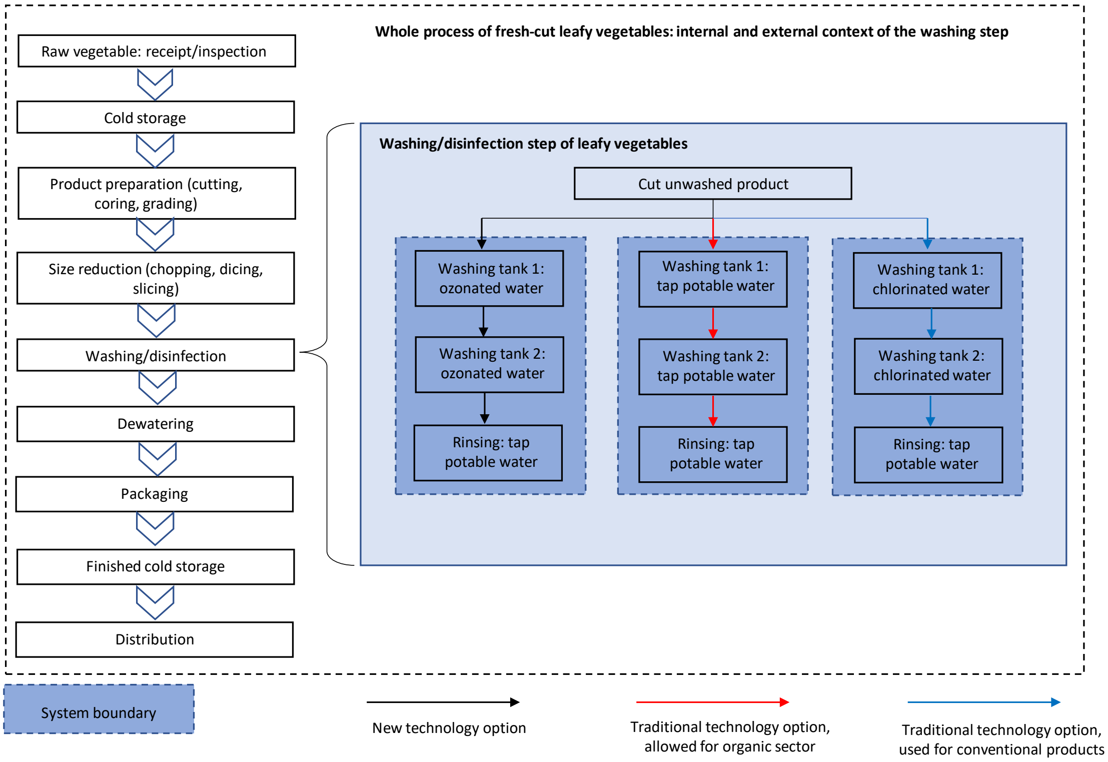


Fig. 1. System boundaries of the case and the two benchmark technologies.

Step 2. Assessment

An overview of potentially relevant criteria for environmental sustainability, nutritional and sensory quality aspects is given in Figure 2.

Substep 2.1 Detailed characterisation of relevant criteria

As reported above regarding the environmental sustainability, a LCA of the processing phase of fresh-cut industry applying the conventional washing with chlorinated water, has highlighted that the environmental impact associated to the processing phase is dominated by the washing and packaging operations, due to electricity and water consumption (Fusi et al., 2016). In addition, it has been highlighted by Ölmez (2017) that the main industrial impact on water resources is due to the highly polluted waste water discharges rather than the amount of water used. However, no LCA data are available on the literature referred to a process involving OWW or WW, thus it is not straightforward to evaluate the criteria of electricity and water consumption and of waste water production for these two processes. Nevertheless, some qualitative/semi-quantitative information are available on water use and quality of waste water for the OWW and WW processes, thus the two criteria of “Water use” and “Toxicity” (“Freshwater ecotoxicity”) were included in the evaluation.

Based on studies on the effect of washing with ozonated water on the quality fresh-cut leafy vegetables (Beltrán et al., 2005; Ölmez et al., 2009; Ölmez, 2012), "Concentration of micronutrients", "Concentration of phytochemicals", "Microbial characteristics" and "Presence of contaminants" were identified as relevant criteria of nutritional quality, even though the caveats highlighted above concerning the role of microbial characteristics as quality mandatory prerequisite should not be forgotten. As regards sensory quality "Enjoyment" was selected as relevant criterium.

All of these criteria within the nutritional and sensory quality aspects are also relevant for the analysis of naturalness.

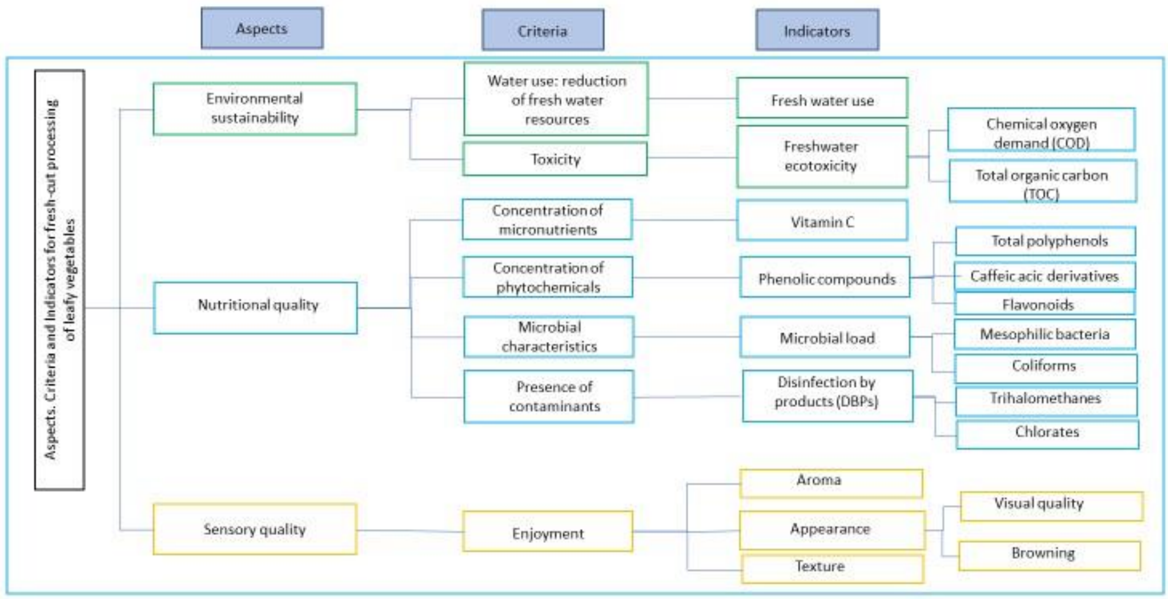


Figure 2. Overview of relevant criteria for the three aspects defining organic food quality.

Substep 2.2 Selection of indicators and parameters for the relevant criteria

Indicators and parameter selected to describe the relevant criteria are shown in Figure 2 and listed in Table 1.

Substep 2.3 Analysis of the relevant indicators

In the above mentioned LCA study of the fresh-cut industrial process involving CW estimation on the amount of water used were given (Fusi et al., 2016). A qualitative indication of reduced water use in a process involving OWW were provided by Garcia et al. (2003), based on a reduced, approximately by half with respect of conventional chlorine based washing, rate of water turnover in the washing tanks. A similar estimation was provided by a private company providing systems for water disinfection treatments (De Nora, 2016, confidential information). In a process involving WW washing, generally, a high rate of water turnover in washing tanks is applied, and thus higher volumes of water are consumed. However, no data on this are available in the literature, while investigations carried out at a commercial level found that when the water in the washing baths was not changed often enough, microorganisms accumulated, resulting in an increasing total microbial load in the processing water during production. As a consequence, Authors of this paper rose doubts about the possibility to control microbial quality by washing with water and concluded that the wash process with water cannot be identified as an intervention step in the fresh-cut produce industry (Holvoet et al., 2012). Data on "Freshwater ecotoxicity" was based on evaluation on quality of waste water performed in the study by Ölmez et al., (2009b), where Chemical oxygen demand (COD) and Total organic carbon (TOC) of the waste water produced by the three washing treatments considered in this assessment were measured.

To quantify indicators of nutritional and sensory quality aspects, the studies of Beltrán et al. (2005), López-Gálvez et al. (2019) and Ölmez et al. (2009b), in which nutritional and sensory quality of fresh-cut lettuce subjected to different washing treatments were analysed, were used. In two of these studies (Beltrán et al. (2005) and Ölmez et al. (2009b)), washing treatments were tested by an experimental test carried out at a laboratory level. In the third study (López-Gálvez et al. (2019)), washing treatment using chlorine was evaluated by experimental tests carried out at a commercial level, in processing lines of a commercial factory. Data on concentration of micronutrients (vitamin C and β-carotene), microbial characteristics (plate count of aerobic mesophilic bacteria, psychotrophic bacteria and *Enterobacteriaceae*) and sensory attributes (overall visual quality, cut edge tissue browning, firmness and aroma) were collected from the study by Ölmez et al., (2009b), where the effects of washing of fresh-cut lettuce in ozonated water, at 2 ppm at 10°C for 2 minutes, were compared with effects of washing in chlorinated water (100 ppm) or in cold water. After the washing treatment fresh-cut lettuce samples were packaged under active modified atmosphere packaging (MAP) (3 kPa O_2 and 7 kPa CO_2 balanced with nitrogen) using polypropylene bags, and then stored at 4°C for 12 days. Data reported in Table 1 are, for each indicator, average data observed on lettuce samples after 5 and 7 days of cold storage. Data on microbial characteristics (mesophilic bacteria and coliforms), vitamin C and phytochemicals were collected also from the study by Beltran et al. (2005), where washing of fresh-cut lettuce in ozonated water was carried out at 10 ppm, at 4°C for 3-5 minutes, whereas washing in chlorinated water (at 80 ppm) and in cold water were carried out at 4°C for 3 minutes. After the washing treatment lettuce samples were packaged under active MAP (4 kPa O_2 and 10 kPa CO_2 balanced with nitrogen) using polypropylene bags, and then stored at 4°C for 13 days. Data reported in Table 1 were determined on lettuce samples after 5 days of storage at 4°C, under MAP conditions.

In addition, to quantify indicators of nutritional quality aspects related to the criterium of presence of contaminants, data on the formation of disinfection by-products (DBPs) were collected by the study by López-Gálvez et al. (2019). The main classes of DPPs formed in the process are the more volatile Trihalomethanes and the non-volatile Chlorates. Data reported in Table 1 were obtained from an experimental test performed on a fresh-cut lettuce processing line, and were the average values observed in product samples collected at different times from the processing line. For the cases of OWW and WW processes no direct data were available. However, some estimation may be done based on available information. It is plausible to assume that washing with potable water may produce very low levels of DBPs, due to the chlorine level present in the tap water. As regards OWW, it has been reported that the lack of formation of chlorinated DBPs is one of the advantages of the use of ozone for the treatment of drinking water when compared to the traditional use of chlorine (Richardson et al., 2012; Sedlak et al., 2011). Thus, it may be assumed that low levels of chlorinates DBPs residue on fresh-cut product as a result of OWW (Ölmez et al., 2012). However, it has to be taken into account that more than 60% of the assimilable organic carbon formed during water ozonation is not characterised yet, and nothing is known about their potential effects. In addition, when high levels of bromide are present in water, brominated DBPs can be formed as a result of ozonation, and brominated DBPs are known to have a considerably high carcinogenic and mutagenic potential (Ölmez et al., 2012).

Table 1. Characterisation and analysis of relevant criteria within the three aspects for the three evaluated washing treatments: OWW, WW, CW.

Aspect	*Criteria*	*Indicator*	*Parameter*	*OWW absolute value*	*WW absolute value*	*CW absolute value*	*OWW normalised value vs WW*	*OWW normalised value vs CW*	*Rating of OWW vs WW*	*Rating of OWW vs CW*	*Remarks*
Environmental sustainability	*Water use: reduction of fresh water resources*	Fresh water use	dm^3/kg of product	19[1]	High volumes	38	-	-	2[1]	1[1]	
	Toxicity	Freshwater ecotoxicity. Chemical oxygen demand (COD)	mg O_2/L	7.50	22.80	18.20	33	41	2	2	
	Toxicity	Freshwater ecotoxicity. Total organic carbon (TOC)	mg/L	3.82	4.99	5.16	77	74	0	1	
Nutritional quality	*Concentration of micronutrients*	Vitamin C[3]	mg/100 g f.w.	1.3	1.5	1.5	87	87	0	0	
	Concentration of micronutrients	Vitamin C[4]	mg/100 g f.w.	2.3	3.2	2.9	72	79	-1	0	
	Concentration of micronutrients	β-carotene[3]	mg/100 g f.w.	1.4	1.5	1.5	93	93	0	0	
	Concentration of phytochemicals	Caffeic acid derivatives[4]	mg/100 g f.w.	21.0	20.5	23.5	102	89	0	0	
	Concentration of phytochemicals	Flavonoids[4]	mg/100 g f.w.	3.5	4.1	2.4	85	146	0	1	
	Concentration of phytochemicals	Total polyphenols[4]	mg/100 g f.w.	24.5	24.6	25.9	100	95	0	0	
	Microbial characteristics	Mesophilic bacteria[4]	Log CFU/g	2.6	4.7	1.9	55	137	1	-1	
	Microbial characteristics	Coliforms[4]	Log CFU/g	1.6	3.7	0.8	43	200	2	-2	
	Microbial characteristics	Aerobic mesophilic bacteria[3]	Log CFU/g	6.3	7.3	6.3	86	100	0	0	

	Microbial characteristics	Psychotrophic bacteria[3]	Log CFU/g	5.8	6.8	5.8	85	100	0	0	
	Microbial characteristics	*Enterobacteriaceae*[3]	Log CFU/g	3.9	5.6	3.7	70	105	1	0	
	Presence of contaminants	Chlorates	µg/kg	Low level	Very low level	107.8	-	-	-1[2]	1[2]	
	Presence of contaminants	Trihalomethanes	µg/kg	Low level	Very low level	10.1	-	-	-1[2]	1[2]	
Sensory quality	Enjoyment	Visual quality[4]	Sensory score	8.0	7.0	7.7	114	104	0	0	1: poor; 9: excellent.
	Enjoyment	Browning[4]	Sensory score	1.0	1.0	1.0	100	100	0	0	1: no browning; 5: severe browning.
	Enjoyment	Visual quality[3]	Sensory score	8.0	6.1	7.8	131	102	1	0	9= excellent; 1 =very poor.
	Enjoyment	Browning[3]	Sensory score	1.55	3.2	1.85	48	84	2	0	5=severe; 1=none.
	Enjoyment	Texture/Firmness[3]	Sensory score	4.7	3.5	4.4	134	107	1	0	5= very good; 1= poor.
	Enjoyment	Aroma[3]	Sensory score	4.55	3.5	3.85	130	118	1	0	5= very good; 1= poor.

Notes:

[1]estimation based on qualitative information

[2]Direct experimental data not available

[3] Data from Ölmez et al. 2009

[4] Data from Beltran et al 2005

Substep 2.4 Evaluation of quantified indicators by comparison with an alternative processing method and raw materials

The absolute impacts for the indicators used to describe the criteria for the three aspects were normalized always using the absolute value of WW (Benchmark 1) as the upper range of the scale 0 to 100 (**OWW normalised value vs WW*)*** and also using the absolute value of CW (Benchmark 2) as the upper range of the scale 0 to 100 (**OWW normalised value vs CW*)*** (Table 1). For the normalised parameter values the score ranges in Table 2 were used to transfer the values into a scale from -2 to 2 as this allows to rate the score values for OWW relative to WW and CW(Table 2). Taking into account the variability of the effect of a processing factor, in this case the washing treatment, on the chemical composition of a biological system, like a vegetable food product, or on its microbial count, a range of ≥ 75 ; ≤ 125 around the value of 100 was selected to assess the product as "the same" (rating 0) to the benchmark for the corresponding indicator, rather than the single value of 100. A normalized value within this range may plausibly suggest a minor, if significant, effect, when generalised for all specimens of the same product (here, fresh-cut lettuce). Negative ratings represent characteristics that are worse for the respective indicator of the proposed technology (OWW) compared to the existing technology (WW or CW). Positive values indicate that a characteristic is better in the product processed with the new technology compared to the product processed with the existing technology. For environmental sustainability indicators, for microbial characteristics and browning, lower normalised parameter values corresponded to the better for the environment, nutritional or sensory aspect, and this needs to be accounted for when attributing score ranges to the rating scale (Table 2).

Table 2. Transfer of normalized values to rated scale.

	Environmental sustainability	Nutritional/sensory quality, except for microbial characteristics and browning	Nutritional/sensory quality, only for microbial characteristics and browning
Rating scale	Condition for normalized OWW value	Condition for normalized OWW value	Condition for normalized OWW value
2 = far better	**< 50**	**> 150**	**< 50**
1 = better	**≥ 50; < 75**	**>125 ; ≤ 150**	**≥ 50; < 75**
0 = same	**≥ 75 ; ≤ 125**	**≥ 75 ; ≤ 125**	**≥ 75 ; ≤ 125**
-1 = worse	**>125 ; ≤ 150**	**≥ 50; < 75**	**>125 ; ≤ 150**
-2 = far worse	**> 150**	**< 50**	**> 150**

As highlighted in Table 1 no quantitative data were available about water consumption for OWW and WW washing treatment. However, as reported above, qualitative information available would suggest that OWW may give rise to significant reduction of water consumption with respect to CW, and, plausibly to even higher water savings when compared to processes involving WW. Accordingly, tentative ratings have been attributed to OWW vs WW (2) and OWW vs CW (1). As regards, the quality of produced waste water, data reported on COD and TOC in samples of waste water obtained in a lab scale experiment, showed a clear favourable effect of OWW with respect to both WW and CW for COD.

Among the indicators analysed within the nutritional quality aspects, for the presence of contaminants (DBPs) no data were available for OWW and WW and ratings were tentatively attributed based on the above mentioned qualitative information available. Tentative ratings (-1) for the presence of contaminants for OWW vs WW washing treatment, and (1) OWW vs CW for have been provided based on remarks reported in the previous section. In one study, a negative effect of OWW with respect to WW on vitamin C content was highlighted. On the contrary, in one study microbial characteristics were better in the fresh-cut product treated by the OWW vs WW, but worse when compared to CW. As regards the sensory quality, in one study fresh-cut product obtained by OWW showed higher quality level for all the sensory attributes considered with respect to WW, whereas only minor differences were observed with respect to CW.

For the analysis of naturalness, the indicator values for OWW describing criteria related to the nutritional aspect were compared to the respective values of unprocessed raw lettuce (URL), whereas no data were available for this comparison for sensory indicators (Table 3). Data were collected from the study by Ölmez et al. (2009), and in this case they referred to lettuce samples analyses just after washing treatment at the beginning of the storage time, rather than after some days of storage. As in the comparison of OWW treated lettuce with fresh-cut product obtained by WW or CW, normalized scores were transferred to a rating scale ranging from -2 to 2. As regards microbiological quality OWW treated lettuce showed clearly lower microbial counts and better rating at least for one of the three measured indicators. On the other hand, micronutrient content was negatively affected by the OWW treatment, both for vitamin C and β-carotene content. A difference in naturalness could be observed for the presence of contaminants, DBPs. The study by López-Gálvez et al. (2019) observed not detectable level of both chlorates and trihalomethanes on raw unwashed lettuce, while no direct data are available on DBPs levels in lettuce subjected to OWW. However, in this case, based on information of use of ozone for treatment of drinking water, it is plausible to assume that the level of chlorinated DBPs in OWW treated product should be low. Thus, we proposed a tentative rating of -1 for these indicators.

Table 3. Naturalness check of OWW fresh-cut lettuce with unprocessed raw lettuce (URL).

Aspect	Criteria	Indicator	Parameter	OWW absolute value	URL absolute value	OWW normalised value	URL normalised value	Rating	Remarks
Nutritional quality	*Concentration of micronutrients*	Vitamin C	mg/100 g f.w.	1.4	2.2	64	100	-1	
	Concentration of micronutrients	*β*-carotene	mg/100 g f.w.	1.6	2.2	73	100	-1	
	Microbial characteristics	Aerobic mesophilic bacteria	Log CFU/g	5.6	6.8	82	100	0	
	Microbial characteristics	Psychotrophic bacteria	Log CFU/g	4.4	5.6	79	100	0	
	Microbial characteristics	*Enterobacteriaceae*	Log CFU/g	3.0	4.6	65	100	1	
	Presence of contaminants	Chlorates	μg/kg	Low level	n.d.	-	100	-1	
	Presence of contaminants	Trihalomethanes	μg/kg	Low level	n.d.	-	100	-1	

In order to better classify the results of the naturalness check of OWW treated fresh-cut lettuce with unprocessed raw lettuce, the same analysis was carried out for lettuce processed by WW (Table 4) or CW (Table 5). In the case of WW treatment, the benefit on the microbiological quality observed in the case of OWW were lost, but the negative effects on micronutrients content were mitigated. Even though, no direct experimental data are available, it is plausible to assume that the WW treatment does not cause a significant formation of chlorinated DBPs, thus it is possible to assume a rating of 0 for the relevant parameters.

Table 4. Naturalness check of WW fresh-cut lettuce with unprocessed raw lettuce (URL).

Aspect	Criteria	Indicator	Parameter	WW absolute value	URL absolute value	WW normalised value	URL normalised value	Rating	Remarks
	Concentration of micronutrients	Vitamin C	mg/100 g f.w.	1.9	2.2	86	100	0	
	Concentration of micronutrients	β-carotene	mg/100 g f.w.	1.8	2.2	82	100	0	
	Microbial characteristics	Aerobic mesophilic bacteria	Log CFU/g	6.5	6.8	96	100	0	
Nutritional quality	*Microbial characteristics*	Psychotrophic bacteria	Log CFU/g	5.1	5.6	91	100	0	
	Microbial characteristics	*Enterobacteriaceae*	Log CFU/g	4.2	4.6	91	100	0	
	Presence of contaminants	Chlorates	μg/kg	Very Low level	n.d.	-	100	0	
	Presence of contaminants	Trihalomethanes	μg/kg	Very Low level	n.d.	-	100	0	

An ambivalent profile was obtained in the case of CW treatment, where the microbiological quality of the fresh-cut product was better than the unprocessed lettuce, even though the rating was positive only for one indicator, whereas the formation of DBPs, as measured at a commercial scale (López-Gálvez et al., 2019), highlighted a clear loss of naturalness in CW treated product with respect to the unprocessed lettuce, where no detectable levels of DBPs were observed.

Table 5. Naturalness check of CW fresh-cut lettuce with unprocessed raw lettuce (URL).

Aspect	Criteria	Indicator	Parameter	CW absolute value	URL absolute value	CW normalised value	URL normalised value	Rating	Remarks
	Concentration of micronutrients	Vitamin C	mg/100 g f.w.	1.5	2.2	68	100	-1	
	Concentration of micronutrients	β-carotene	mg/100 g f.w.	1.7	2.2	77	100	0	
	Microbial characteristics	Aerobic mesophilic bacteria	Log CFU/g	5.3	6.8	78	100	0	
Nutritional quality	*Microbial characteristics*	Psychotrophic bacteria	Log CFU/g	4.5	5.6	80	100	0	
	Microbial characteristics	*Enterobacteriaceae*	Log CFU/g	3.1	4.6	67	100	1	
	Presence of contaminants	Chlorates	μg/kg	107.8	n.d.	-	100	-2	
	Presence of contaminants	Trihalomethanes	μg/kg	10.1	n.d.	-	100	-2	

Step 3 Overall evaluation of organic food quality

Substep 3.1 Weighting of indicators and aggregating to criterion level

If criteria are described by one indicator, the weighting factor for the indicator is 100% (Table 6 and 7). In this example, this is the situation with environmental sustainability criterium of water use. On the contrary, the criterion “Toxicity” is described by two indicators and a weighting factor of 50% was selected. (Table 6 and 7).

A low weighting factor (5% for each data source) was attributed to concentration of vitamin C, because the intake of vitamin C seemed to be of quite minor importance (3.2 mg of vitamin C contained in 100g of lettuce, the highest value reported, corresponding to 4-5% of the recommended dietary intake for vitamin C). On the other hand, a high weighting factor (90%) was attributed to β-carotene because the intake of β-carotene from lettuce seemed to be of higher nutritional relevance (1.5 mg of β-carotene contained in 100g of lettuce corresponding to 50-62% of the recommended dietary intake for vitamin A). For indicators of other nutritional criteria the same weighting factor was attributed. It is to be stressed here that these remarks apply to the case of lettuce, but would not necessarily appropriate for other vegetable species processed into fresh-cut products, such as, for instance, spinach or carrots, which may be characterised by different content of individual vitamins. As a consequence different weighting factors should be considered for other fresh-cut vegetables.

Regarding sensory quality and enjoyment, the same weighting factor was attributed to each indicator, for each data source (16%).

For the naturalness check only the nutritional quality aspect was considered because only for this aspect experimental data were available (Table 8, 9, 10). In this case, the same weighting factors were applied to all indicators, because, independently of their relevance for the nutritional significance of lettuce consumption, each of them gives a measure of the change of product composition as a result of the processing step considered.

Table 6. Comparison of OWW treated fresh-cut lettuce with fresh-cut lettuce treated by WW (Benchmark 1) to evaluate organic food quality.

Aspect	Aspect weighting factor	Aspect rating	Criteria	Criteria weighting factor	Indicator	Indicator weighting factor	Rating criteria
Environmental sustainability	33%	***1.5***	*Water use: reduction of fresh water resources*	50%	Fresh water use	100%	2
			Toxicity	50%	Chemical oxygen demand (COD)	50%	2
					Total organic carbon (TOC)	50%	0
							Aspect rating 1.5
Nutritional quality	33%	***0.14***	*Concentration of micronutrients*	20%	Vitamin C	5%	0
					Vitamin C	5%	-1
					β-carotene	90%	0
			Concentration of phytochemicals	5%	Caffeic acid derivatives	33%	0
					Flavonoids	33%	0
					Total polyphenols	33%	0
			Microbial characteristics	50%	Mesophilic bacteria	20%	1
					Coliforms	20%	2
					Aerobic mesophilic bacteria	20%	0
					Psychotrophic bacteria	20%	0

					Enterobacteriaceae	20%	1
			Presence of contaminants	25%	Chlorates	50%	-1
					Trihalomethanes	50%	-1
						Aspect rating	***0.14***
Sensory quality	33%	***0.833***	Enjoyment	100%	Visual quality	16.6%	0
					Browning	16.6%	0
					Visual quality	16.6%	1
					Browning	16.6%	2
					Firmness	16.6%	1
					Aroma	16.6%	1
						Aspect rating	***0.833***

Overall rating 0.823

Table 7. Comparison of OWW treated fresh-cut lettuce with fresh-cut lettuce treated by CW (Benchmark 2) to evaluate organic food quality.

Aspect	Aspect weighting factor	Aspect rating	Criteria	Criteria weighting factor	Indicator	Indicator weighting factor	Rating criteria
Environmental sustainability	33%	***1.25***	*Water use: reduction of fresh water resources*	50%	Fresh water use	100%	1
			Toxicity	50%	Chemical oxygen demand (COD)	50%	2
					Total organic carbon (TOC)	50%	1
						Aspect rating	***1.25***
Nutritional quality	33%	***-0.033***	*Concentration of micronutrients*	20%	Vitamin C	5%	0
					Vitamin C	5%	0
					β-carotene	%	0
			Concentration of phytochemicals	5%	Caffeic acid derivatives	33%	0
					Flavonoids	33%	1
					Total polyphenols	33%	0
			Microbial characteristics	50%	Mesophilic bacteria	20%	-1
					Coliforms	20%	-2
					Aerobic mesophilic bacteria	20%	0
					Psychotrophic bacteria	20%	0
					Enterobacteriaceae	20%	0
			Presence of contaminants	25%	Chlorates	50%	1
					Trihalomethanes	50%	1
						Aspect rating	***-0.033***
Sensory quality	33%	***0.000***	Enjoyment	100%	Visual quality	16.6%	0
					Browning	16.6%	0
					Visual quality	16.6%	0
					Browning	16.6%	0
					Firmness	16.6%	0
					Aroma	16.6%	0
						Aspect rating	***0.000***

Overall rating 0.417

Substep 3.2 Weighting of criteria and aggregating to aspect level

It was assumed that both criteria related to environmental sustainability have equal weights (Table 6 /7).

On the contrary, different weighting factors were attributed to criteria related to the nutritional aspect. A weighting factor of 50% was attributed to microbial characteristics to take into account the relevance of microbial requirements for food safety, as discussed above. A relatively low weighting factor was attributed to concentration of micronutrients, because only the intake of β-carotene from lettuce seemed to be of nutritional relevance, whereas the intake of vitamin C seemed to be of quite minor importance. A very low weighting factor was attributed to the concentration of phytochemicals criterium, based on the relative low intake of phenolic compounds from lettuce (based on a content of 25 mg/100 g of fresh weight) when compared to estimates of total dietary intake of phenolic compounds from all food sources (approximately 1 g day, Scalbert et al., 2000).

The rating score for each aspect was obtained by multiplying the rating score of each criteria with the criteria weighting factor and then summing the products (weighted mean, Table 6 and 7). For the naturalness check, the same weighting factor was applied to each criterium and the rating score for nutritional quality was calculated accordingly (Table 8, 9, 10).

Substep 3.3. Weighting of aspects and aggregating aspect scores to overall score for organic food quality and to naturalness score

For simplicity it was assumed within this example that all aspects are equally important to describe organic food quality and, therefore, the same weighting factor was given to each aspect for the aggregation to the overall score (Table 6 and 7). The overall score was obtained by multiplying the rating score of each aspect by the aspect weighting factor and summing the products. Under all assumptions taken within this example, the overall score for organic food quality reached is 0.823 for OWW vs WW (Benchmark 1) (Table 6) and 0.417 for OWW vs CW (Benchmark 2) (Table 7).

In the first case, OWW vs WW, the overall score 0.823 was due primarily to the rating associated to Environmental sustainability (1.5), then to the contribution of sensory quality (0.833), whereas nutritional quality resulted to have a minor relevance, with a relatively low rating (0.14). Thus, expected reductions in water consumption and better quality of waste water seem to be the most important factor in the better performance of the OWW technology when compared to WW, in terms of organic food quality. Also a significantly better sensory quality contributes to the better overall score of OWW vs WW. On the other hand, in the second case, OWW vs CW, the overall lower score of 0.417 was due essentially to the rating associated to Environmental sustainability (1.25), whereas both nutritional and sensory ratings (-0.033 and 0.000) had a negligible contribution to the overall score.

For calculating the score for naturalness, sensory data were not available and thus the assessment was based only on the nutritional quality aspect. The overall rating was calculated in the same manner as for the score for organic food quality (see above). When checking for naturalness of OWW treated fresh-cut lettuce compared to unprocessed lettuce an overall score of -0.556 was obtained under all assumptions taken within this example (Table 8).

Table 8. Naturalness for OWW treated fresh-cut lettuce (comparison of OWW treated fresh-cut lettuce to unprocessed raw lettuce).

Aspect	Aspect weighting factor	Aspect rating	Criteria	Criteria weighting factor	Indicator	Indicator weighting factor	Rating criteria
Nutritional quality	100%	***-0.556***	*Concentration of micronutrients*	33%	Vitamin C	50%	-1
					β-carotene	50%	-1
			Microbial characteristics	33%	Aerobic mesophilic bacteria	33%	0
					Psychotrophic bacteria	33%	0
					Enterobacteriaceae	33%	1
			Presence of contaminants	33%	Chlorates	50%	-1
					Trihalomethanes	50%	-1
							Aspect rating -0.556

Overall rating -0.556

Table 9. Naturalness for WW treated fresh-cut lettuce (comparison of OWW treated fresh-cut lettuce to unprocessed raw lettuce).

Aspect	Aspect weighting factor	Aspect rating	Criteria	Criteria weighting factor	Indicator	Indicator weighting factor	Rating criteria
Nutritional quality	100%	***0.000***	*Concentration of micronutrients*	33%	Vitamin C	50%	0
					β-carotene	50%	0
			Microbial characteristics	33%	Aerobic mesophilic bacteria	33%	0
					Psychotrophic bacteria	33%	0
					Enterobacteriaceae	33%	0
			Presence of contaminants	33%	Chlorates	50%	0
					Trihalomethanes	50%	0
							Aspect rating 0.000

Overall rating 0.000

Table 10. Naturalness for CW treated fresh-cut lettuce (comparison of OWW treated fresh-cut lettuce to unprocessed raw lettuce).

Aspect	Aspect weighting factor	Aspect rating	Criteria	Criteria weighting factor	Indicator	Indicator weighting factor	Rating criteria
Nutritional quality	100%	***-0.722***	*Concentration of micronutrients*	33%	Vitamin C	50%	-1
					β-carotene	50%	0
			Microbial characteristics	33%	Aerobic mesophilic bacteria	33%	0
					Psychotrophic bacteria	33%	0
					Enterobacteriaceae	33%	1
			Presence of contaminants	33%	Chlorates	50%	-2
					Trihalomethanes	50%	-2
							Aspect rating -0.722

Overall rating -**0.722**

For the further evaluation of the score obtained for naturalness in the comparison of OWW treated fresh-cut lettuce with unprocessed lettuce it is helpful to compare this score also with the score for naturalness of fresh-cut lettuce processed with the existing technology, WW or CW. As can be seen from Table 9, in the first case, the overall score for naturalness of fresh-cut lettuce obtained by WW results in 0.000, highlighting no effect of the processing on the naturalness of the product. Thus, check of naturalness suggests that when limiting the assessment to product naturalness, and in this case, neglecting the environmental impact of the process, the overall rating is definitely better in the case of WW when compared to OWW, while the overall rating to evaluate organic food quality (Table 6) pointed to an opposite conclusion.

Regarding the evaluation of the naturalness of the CW process, the overall score amounted to -0.722, suggesting a more marked loss of naturalness when compared to the OWW treatment, which was mainly due to the higher level of contaminants (DBPs) formed as a result of the use of chlorine.

3. Feedback towards assessment framework

The draft assessment framework will be refined to the final version and integrated into the CoP.
To be completed

4. Perspective on ‘desktop studies’ with existing data

5. Summarizing conclusions

To be completed

6. Appendix

I. Protocol for an assessment of quality of processed organic food products (online)
II. Assessment table
III. Group discussion questionnaire
IV. Organic processing assessment post-workshop 1 survey
V. Analysis of workshop 1 to test the Assessment framework

Date: 12.05.2020

Country: Denmark

Product: Milk

Existing processing method: Pasteurization

Alternative processing method: High pressure processing

This file contains results on:

Table 1: Duration of each task in workshop 1

Table 2: Capability of participants to independently perform the tasks

Table 3: Clarifications of tasks provided by the facilitator

Table 4: Errors that participants made when performing tasks

Table 5: Other comments by participants related to the performed tasks

Summary of general comments related to the workshop and the assessment

List of recommendations for improvement and of positive aspects of the workshop

Table 1. Duration of each task in workshop 1

	Start time	**End time**	**Duration**
STEP 1: Establishing the context			
Choosing a product + Choosing alternative technology + Choosing existing technology	13.40	13.46	6 min
Listing processing steps existing technology + Listing processing steps alternative technology	14.05	14.10	5 min
Listing inputs outputs existing technology + Listing inputs outputs alternative technology	14.10	14.25	15 min
Selecting criteria of environmental sustainability	14.27	14.36	9 min
Selecting criteria of nutritional quality	14.36	14.43	7 min
Selecting criteria of sensory quality	14.43	14.49	6 min
STEP 2: Assessment			
Selecting indicators of environmental sustainability + Parameters environmental sustainability	14.50	15.05	15 min
Selecting indicators of nutritional quality + Parameters nutritional quality	15.05	15.05	1 min
Selecting indicators of sensory quality + Parameters sensory quality	15.05	15.10	5 min

Table 2. Capability of participants to independently perform the tasks

	Did facilitator need to clarify the task?	**How many times did the facilitator intervene?**	**Did facilitator solve this task, or parts of it instead of participants?**	**To what extent were participants able to perform this task?***
STEP 1: Establishing the context				
Choosing a product + Choosing alternative technology	YES	5	NO	Almost fully capable
Choosing existing technology				
Listing processing steps existing technology + Listing processing steps alternative technology	NO	4	NO	Almost fully capable
Listing inputs outputs existing technology + Listing inputs outputs alternative technology	YES	4	NO	Almost fully capable

Selecting criteria of environmental sustainability	YES	5	NO	Almost fully capable
Selecting criteria of nutritional quality	NO	1	NO	Almost fully capable
Selecting criteria of sensory quality	NO	0	NO	Fully capable
		STEP 2: Assessment		
Selecting indicators of environmental sustainability + Parameters environmental sustainability	YES	4	NO	Almost fully capable
Selecting indicators of nutritional quality + Parameters nutritional quality	NO	0	NO	Fully capable
Selecting indicators of sensory quality + Parameters sensory quality	NO	0	NO	Fully capable

* Scale:

- Fully capable (facilitator did not intervene at all – participants read and finished the task without facilitator's help)
- Almost fully capable (facilitator needed to explain what the participants have to do)
- Partially capable (facilitator needed to clarify what and how exactly participants have to do)
- Somewhat not capable (facilitator performed some parts of the task instead of participants)
- Not at all capable (facilitator had to perform the whole task instead of participants)

Table 3. Clarifications of tasks provided by the facilitator

	What did facilitator need to clarify to participants?
STEP 1: Establishing the context	
Choosing a product + Choosing alternative technology + Choosing existing technology	1. The facilitator clarified that the process that the company decides to look at should be a product 2. Answered a question from a participant asking "The purpose here is to test the assessment formu you choose?". The participant is asking this question in relation to the group being asked to cho 3. To clarify for the group which two processes had been chosen
Listing processing steps existing technology + Listing processing steps alternative technology	1. The facilitator clarified that participants should look at the assessment of different steps of the tv and if so, the steps should be included in the assessment. 2. To not take transportation of the product and shelf life into consideration, since we are only goi that it should be considered that the product is safely produced
Listing inputs outputs existing technology + Listing inputs outputs alternative technology	1. The facilitator clarified that if some steps are the same for each processing technology, they don (The participants discussed whether or not the participants should compare processing steps if th they are different, they should look at them. 2. That participants should choose inputs/outputs that they find relevant. 3. Explained what output means – means ingredients, resources, sub products or if something is pr 4. Asked them to think which outputs could be relevant in terms of environment
Selecting criteria of environmental sustainability	1. How to use the Excel sheet 2. That they should include anything they find important. Do not only include criteria for which th
Selecting criteria of nutritional quality	1. Participant asked what "inner quality" and "holistic quality" means. Facilitator was not able to a
Selecting criteria of sensory quality	-
STEP 2: Assessment	
Selecting indicators of environmental sustainability + Parameters environmental sustainability	1. The participants asked if they need to fill out everything (Indicator, parameter and substep 1.2b: during processing). Facilitator answers that they should fill out indicators, parameters - optional Clarifies that they can fill out substep 1.2b afterwards if they have time and that indicators and p 2. Clarified that parameter means unit.
Selecting indicators of nutritional quality + Parameters nutritional quality	-
Selecting indicators of sensory quality + Parameters sensory quality	-

Table 4. Errors that participants made when performing tasks

	What errors did participants make?
STEP 1: Establishing the context	
Choosing a product + Choosing alternative technology	
Choosing existing technology	
Listing processing steps existing technology + Listing processing steps alternative technology	Not a mistake/error as such, but some of the participants discussions were potentially out of scope in these types of discussions are required in this step, and if yes, how to deal with it. 1. The participants started talking about different cleaning steps that are used in the two proce 2. Different types of packaging were also discussed, and how these should have different env and due to different packaging materials used for them.
Listing inputs outputs existing technology + Listing inputs outputs alternative technology	Not a mistake/error as such, but this was maybe a bit out of scope in this step: 1. The participants started talking about different cleaning steps that are used in the two proce 2. Different types of packaging were also discussed, and how these should have different env and due to different packaging materials used for them.
Selecting criteria of environmental sustainability	The participants talked about packaging, logistics/transportation to sites and transportation of materia method - maybe a bit out of scope
Selecting criteria of nutritional quality	
Selecting criteria of sensory quality	
STEP 2: Assessment	
Selecting indicators of environmental sustainability + Parameters environmental sustainability	
Selecting indicators of nutritional quality + Parameters nutritional quality	
Selecting indicators of sensory quality + Parameters sensory quality	

Table 5. Other comments by participants related to the performed tasks

	Other comments
STEP 1: Establishing the context	
Choosing a product + Choosing alternative technology	-
Choosing existing technology	
Listing processing steps existing technology + Listing processing steps alternative technology	1. Participants discussed how the two chosen processing methods are different in the way that one other is a continuous process, so they cannot be compared directly – complicates the compariso

	2. Discussion about how the storage and the use of the two products are very different – one is stor difficult to compare processes/products since they are very different. 3. Legal aspect was mentioned. One of the chosen processes is maybe not legal to produce as it loo mentioned. 4. The participants had some comments to the use of the Excel document. Especially one participa in inputs/outputs and was confused about this. 5. "It is tricky in this Excel sheet, listing the processing steps and all these discussions, where to ca aspects we are discussing now, in my head, it is not logic that this should be a part of the output 6. One participant mentions that it becomes hugely complex to list and capture all processing steps consequences that a technology brings in terms of packaging, limitations of shelf life and so on. 7. Another participant: "A reflection I had had as well – to the project group: All these unit operati provide a safe food product and I don't see any, so far in this evaluation". Here the facilitator ex product has to be safe, so therefore safety is not included in the evaluation.
Listing inputs outputs existing technology + Listing inputs outputs alternative technology	-
Selecting criteria of environmental sustainability	-
Selecting criteria of nutritional quality	-
Selecting criteria of sensory quality	-
STEP 2: Assessment	
Selecting indicators of environmental sustainability + Parameters environmental sustainability	1. One participant did not find it logic how the tab (no 2) in Excel was named. It would be more lo participant finds it confusing the way that they should jump from step 1 to step 2 in the Excel sh 2. The same participant think that "unit" should be used instead of "parameter" and "indicator" sho 3. One participant mentions that the person does not think any of these tasks have anything to do w
Selecting indicators of nutritional quality + Parameters nutritional quality	-
Selecting indicators of sensory quality + Parameters sensory quality	-

Summary of general comments related to the workshop and the assessment

There were some technical issues which delayed the workshop a bit (15min). The participants did not receive a proper link to the online meeting and a meeting link had to be created and sent.

During the presentation of the project there were some interruptions/questions from the participants. Especially some of the participants had a lot of concerns/questions to the project:

- Concern about what will be the outcome of the project/the background of the project
- Concern that it will be impossible to collect data for evaluating processes.
- Concern: The project it too complex
- Questions why three aspects of organic quality have been chosen (nutritional quality, sensory quality and environmental sustainability)
- One participant had the impression that there was a regulatory element to the project. It seems like there has been a misunderstanding/miscommunication before the workshop. That participant questioned why a company should spend time evaluating their processing if it is not required by law/regulatory bodies.

List of recommendations for improvements

- Excel sheet could be improved in a way that it is more logical so that participants will know where to insert information.
- Suggestions to be changed: “Parameter” changed to “unit” and “Indicator” changed to “analysis” or similar. The “criteria” wording was fine, but “parameter” and “indicator” is difficult to understand
- One participant found it unnecessary to list both criteria and indicators – it was a bit the same – difficult to differentiate between the two
- Difficult for some participants to understand the meaning of “input”/”output”
- One participant thinks that listing all steps was unnecessary when they only had to focus on the steps that are different between the two technologies. Suggestion is to only list the processing step that are changing from the existing to the alternative process
- One participant found that the consumer part/perspective was missing

List of positive aspects of the workshop:

- One participant stated that it was interesting taking part in the workshop
- Overall working in Microsoft Teams worked quite well. The participants were used to work in Microsoft Teams, so it was not completely new for them. In the beginning there was a few challenges about the participants getting access to the meeting and getting access to documents in Google Docs and Microsoft Teams (the facilitator did not give necessary permissions to participants before the workshop) but this was solved very fast.
    - A few participants had bad audio equipment and it was sometimes difficult to hear what they were saying.
- It was good to have participants with different backgrounds that could each contribute to different aspects of the workshop

II. Analysis of workshop 1 to test the Assessment framework
Post-test survey

Date: 12.05.2020

Country: Denmark

Product: Milk

Existing processing method: Pasteurization

Alternative processing method: High pressure processing

Table 1: Results of the workshop 1 post-test survey. The question was: “To what extent were the following tasks challenging?”. The numbers in cells represent the number of respondents who selected a particular answer (from extremely challenging to not challenging at all). Three people participated in the survey.

	Extremely challenging	**Very challenging**	**Moderately challenging**	**Slightly challenging**	**Not challenging at all**
STEP 1: Establishing the context					
Choosing a processed organic product			1	1	1
Choosing an alternative processing method for the selected product			1	1	
Listing processing steps of the existing processing method			1		1
Listing inputs and outputs of the existing processing method		2	1		
Listing processing steps of the alternative processing method			1		2
Listing inputs and outputs of the alternative processing method		2	1		
Selecting criteria of the environmental sustainability aspect	3				
Selecting criteria of the nutritional quality aspect	1	1	1		
Selecting criteria of the sensory quality aspect	1		1	1	
Explaining how selected criteria are affected during processing	2	1			
STEP 2: Assessment					
Selecting indicators for environmental sustainability criteria	3				

Selecting indicators for nutritional quality criteria	1	1		1
Selecting indicators for sensory quality criteria	1		1	1
Selecting parameters for environmental sustainability indicators	2		1	
Selecting parameters for nutritional quality indicators	1		2	
Selecting parameters for sensory quality indicators	1		2	

Table 2. Results of the workshop 1 post-test survey. The numbers in cells represent the scores (from 1 (not at all likely) to 10 (extremely likely)) that individual participants selected as an answer to the questions.

Question	Respondent 1	Respondent 2	Res
Do you think you would be able to perform this assessment in the future for another organic food product, alone with your team (without a facilitator)?	1	8	
Would you want to perform this assessment in the future for another organic food product, but alone with your team (without a facilitator)?	1	0	
Would you want to perform this assessment in the future for another organic food product, with a help of a facilitator (such as in the workshop)?	1	0	

Table 3: Results of the workshop 1 post-test survey. The question was: “How do you feel about data collection for identified indicators?”

	How do you feel about data collection for identified indicators?
Respondent 1	We are not planning to perform data collection
Respondent 2	We need help from others (outside of the company) but some data we can collect on our own. We are not planning to perform data collection; it is making it too detailed
Respondent 3	We need help from others (within the company) but some data we can collect on our own

Respondents were asked to provide some open answers (optionally) to the question: Were some tasks particularly difficult for you? If yes, please list them and explain why? Their literal answers are provided below (R=respondent).

1. Results related to listing processing steps and inputs and outputs:

    R1: the sustainability part is more or less impossible 'where to start and where to end'

    R2: listing inputs and outputs, as those descriptions did not make sense to me. and what was the purpose of listing input/output

    R3: you have to have a person attending who knows the process very well in order to be able to fill it out. an alternative is of course to look in the literature, but that takes extra time. this step we could have prepared before the workshop, but we were asked too late to choose a processing method.

2. Results related to selecting criteria for the three aspect:

    R2: you need an extremely versatile group with great knowledge on both known and unknown process. On top the group needs to know almost everything about sustainability/environmental footprint etc. which is complex in itself. I think most people can do a rough estimation of pros/cons for given processes, but the degree of detail that this document asks for is a whole project in itself to provide.

    R3: the criteria that were listed very much reflected the knowledge of the group which was limited in terms of environmental sustainability, we might have forgotten things and added things that were not relevant. it seems very important to have the right competences around the table

3. Results related to selecting indicators and parameters:

    R2: again you require a huge amount of knowledge in the group to perform this task. We were around 8 different competencies from our company, and we struggled. The amount of resources you need for this task is too much.

    R3: again, this step requires experts of the topic contributing. the group present did not have the right knowledge. as already stated the names indicators and criteria should be switched to something else. criteria for unit

Respondents were also asked to provide some open answers (optionally) to the question: Do you think some tasks are not necessary? If yes, please list them and explain why they are not necessary? Their literal answers are provided below (R=respondent).

1. Results related to listing processing steps and inputs and outputs:

   R2: input/output - did not understand the point

   R3: only the processing steps that differ are necessary to list and evaluate, as all other things are being equal (if not at two different processing sites - but then complexity is very high)

2. Results related to selecting criteria for the three aspect:

   R2: I do not think that the degree of detail is needed. you could make it much easier with a rough estimation, which is quite normal (at least i our company) to perform in a project group before testing new technologies anyway.

3. Results related to selecting indicators and parameters:

   R2: ease up on the degree of detail needed. Rough estimations are ok.

   R3: how does this compare with a LCA assessment? are you inventing the wheel?

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